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MOSQUITO REMEDIES AND PREVENTIVES

MOSQUITOES are man's inveterate tormenters and many of them are his dangerous foes. If they were merely a bothersome plague there would be ample justification for unrelenting warfare against them. When, however, we consider that a certain kind of mosquito found in houses in the South will convey yellow fever and breakbone fever from infected to healthy persons and that certain other kinds, by disseminating malaria, render many regions of great fertility almost uninhabitable, no argument for fighting them is necessary.

Swamps, ponds, and marshes are not the only places which breed mosquitoes. A little rain water in an old tin can, an uncared-for sewer trap, or an undrained roof gutter, if neglected, will supply mosquitoes for a neighborhood.

This bulletin describes the measures, substances, and materials, both offensive and defensive, that have been found most effective against these diminutive but serious menaces to our comfort and health. It is a revision of and supersedes Farmers' Bulletin 444, entitled "Remedies and Preventives Against Mosquitoes."

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MOSQUITO REMEDIES AND PREVENTIVES

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IMPORTANCE OF ANTIMOSQUITO WORK

SINCE the discovery that mosquitoes are not only nuisances, but also conveyors of malaria, yellow fever, filariasis, and dengue or breakbone fever, a great deal of remedial work has been done by individuals and communities, and, during the last few years, by the Medical Department of the United States Army and the Public Health Service in the vicinity of camps and cantonments. Many remedies and plans of action have been tested on a large scale, and what follows is a summary of the results.

PROTECTION FROM BITES

PROTECTIVE LIQUIDS

Spirits of camphor or pine oil rubbed upon the face and hands will help to keep mosquitoes away for a time, and this repellent action is also a well-known property of oil of pennyroyal. None of these substances are durable; that is to say, a single application will not last through the night. Oil of citronella is one of the best substances to be used in this way. The odor is objectionable to some people but not to many, and it is efficient in keeping away most mosquitoes for several hours. The best formula tried by the writers was sent to them by C. A. Nash, of New York, and is as follows:

Oil of citronella	1 ounce
Spirits of camphor	1 ounce
Oil of cedar	½ ounce

Ordinarily a few drops on a bath towel hung over the head of the bed will keep the common house mosquitoes away. Where they are very abundant and persistent a few drops rubbed on the face and hands will suffice. Even this mixture, however, loses its efficacy toward the close of a long night. It is the habit of the yellow-fever mosquito [1] to begin to bite at daylight. By that time the average person is sleeping very soundly, and the effects of the mixture will usually have passed largely away. It follows that in the Southern States, where this mosquito occurs, these protective mixtures are not supposed to be as effective as they are in the North. As a matter of fact, however, this last mixture, could it be applied shortly before dawn, would give satisfactory protection.

Oscar Samostz, of Austin, Tex., recommends the following formula:

Oil of citronella	1 ounce.
Liquid petrolatum	4 ounces.

This mixture greatly retards the evaporation of the oil of citronella.

B. A. Reynolds has used successfully in New Orleans 20 minims of oil of citronella to the ounce of petrolatum or lanolin.

Pure kerosene has also been used extensively in the Philippines and to some extent in this country.

SCREENS AND CANOPIES

Such obvious measures as the screening of houses, the use of netting for beds, and the wearing of veils and gloves after nightfall in badly infested regions need no detailed consideration. Screening of houses can not be too carefully done, and adjustable, folding, or sliding window and door screens seem never to be tight; even with well-fitted screens there are often opportunities for mosquitoes to enter; constant care and vigilance alone will prevent this. In certain seasons in mosquito regions, mosquitoes will attempt to make their way through screens and are often able to do so. When they are very numerous, wire screens should be painted lightly with kerosene or oil of citronella.

With bed canopies there should be ample material to admit of a perfect folding of the canopy under the mattress, and the greatest care should be taken to keep the fabric well mended. It often happens in mosquito regions that little care is taken of the bed nettings in the poorer hotels, and it is necessary for perfect protection that a traveler in the Southern States carry with him a pocket "housewife" and he should carefully examine his bed netting every night, prepared to mend all tears and expanded meshes. Veils and nettings for camping in the Tropics or other regions where mosquitoes abound are absolutely necessary. Light frames are made to fit helmetlike over the head and are covered with mosquito netting. Similar frames, readily folded into a compact form, are made to form a bed covering at night, and every camping outfit for work in tropical or malarial regions should possess such framework and plenty of mosquito netting as an essential part of the outfit.

[1] *Aëdes aegypti* L.

The size of the mesh in mosquito bars and window screens is important. Eighteen meshes to the inch, or 16 to the inch if insect screen cloth of heavy-grade wire is used, can be relied upon to keep mosquitoes out, but 14 to the inch admits some of them. However, any good 16-mesh screen cloth will exclude most of the mosquitoes, and this mesh is now generally available. Although copper screen cloth is more expensive than the black or metal coated, its durability is such as to commend its use, especially on the coast or in areas where there is considerable humidity. Painted and galvanized screen cloths will not last long under such conditions, although an occasional coat of screen enamel will greatly lengthen the life of such screens. A coat of enamel is also useful in reducing the size of the openings in 14-mesh screen to exclude small mosquitoes.

SCREENING BREEDING PLACES

Where the rain-water supply is conserved in large tanks, as in cities in the Gulf States, screening is necessary and is now rather generally enforced. Rain-water barrels everywhere should be screened in the same way, except where fish are used to kill the early stages of mosquitoes. A cheap cover for a water barrel can be made by covering a large iron hoop with a piece of stout calico or sacking, free from holes, in such a manner that a good deal of sag is left in the material.

SMUDGES AND FUMIGANTS

Anything that will make a dense smoke will drive away mosquitoes, and various smudges are used by campers. For household use a number of different substances have been tried.

PYRETHRUM POWDERS

Pyrethrum powders, known to the trade as Dalmatian insect powder, Persian insect powder, buhach, and otherwise, are very effective when fresh and pure. Pure powders are the finely ground flower heads of two species of composite plants of the genus Pyrethrum. The essential principle disappears with age and exposure. Pyrethrum powders are generally used dry, and are puffed or blown into crevices frequented by insects, or into the air of a room in which there are mosquitoes. The burning of the powder in a room at night is a common practice. The powder is heaped up in a little pyramid which is lighted at the top and burns slowly, giving out a dense and pungent smoke. Often the powder is moistened and molded roughly into small cones, and after drying it burns readily and perhaps with less waste than does the dry powder. Mosquitoes are stupefied by the smoke and fall to the floor, where they may be swept up and burned. With open windows and constant currents of fresh air this fumigation is not especially effective, and it is necessary, for protection, to sit in a cloud of smoke. The powder may be placed upon a metal screen above the chimney of a kerosene lamp, with the result that the vapor will be dissipated. This is said to be very effective. It is economical in powder, and the odor is slight. Another method of burning the powder is to puff it from an insufflator into a burning gas jet. In New Orleans it has been found

that in order thoroughly to clear houses of mosquitoes pyrethrum must be burned at the rate of 1 pound of powder to every 1,000 cubic feet of space.

MIMMS CULICIDE

This mixture is made of equal parts by weight of carbolic acid crystals and gum camphor. The acid crystals are melted with a gentle heat and poured slowly over the gum, resulting in the absorption of the camphor and a final clear, somewhat volatile liquid with an agreeable odor. This liquid is permanent, and may be kept for some time in tight jars. Volatilize 3 ounces of this mixture over a lamp of some kind for every 1,000 cubic feet of space. A simple apparatus for doing this may be made from a section of stovepipe cut so as to have three legs and an outlet for draft, an alcohol lamp beneath, and a flat-bottom basin on top. The substance is inflammable, but the vapor is not explosive. The vapor is not dangerous to human life except when very dense, but it produces a headache if too freely breathed. Rooms to be fumigated should be made as nearly air-tight as possible.

SULPHUR DIOXIDE

Burning of flowers or flour of sulphur, or of lump sulphur, in a small pot, at the rate of 2 pounds of sulphur for each 1,000 cubic feet of space, is efficient against mosquitoes where fumigation in the case of possible disease-bearing mosquitoes is desired. Metal articles are tarnished by sulphur fumes and should be removed. The house should be closed as tightly as possible, including chimneys.

OTHER FUMIGANTS

According to the late John B. Smith, powdered jimson weed (*Datura stramonium*) can be burned to advantage in houses, 8 ounces being used to fumigate 1,000 cubic feet of space. He stated that it should be made up by the druggist with niter or saltpeter, 1 part to 3 of Datura, so as to burn more freely. According to Doctor Smith the fumes are not poisonous to human beings, are not injurious to fabrics or to metals, and can be used with entire safety. He suggested that it be burned in a tin pan or on a shovel.

USE OF SPRAYS IN DESTROYING MOSQUITOES

Destructive and repellent sprays may serve a useful purpose in combating mosquitoes within dwellings and other buildings. Probably the most effective and available spray for this purpose consists of a kerosene extract of pyrethrum. Many of the commercial fly and mosquito sprays now on the market are essentially of this composition.

In applying such sprays the infested building should be closed tightly and the spray applied freely with a good atomizer. Special attention should be given to spraying behind and beneath furniture and in closets and other protected places where the mosquitoes may be hiding. Not only are the mosquitoes which are struck by the spray killed, but if the air is well filled with the spray mist and the

rooms are kept closed for some time, mosquitoes which are flying about are destroyed.

APPARATUS FOR CATCHING ADULT MOSQUITOES

An interesting homemade apparatus in common use in many parts of the United States is very convenient and effective. It consists of a tin cup or a tin-can cover nailed to the end of a long stick in such a way that a spoonful or so of kerosene can be placed in the cup, which may then, by means of the stick, be pressed up to the ceiling so as to inclose one mosquito after another. When covered over in this way the captured mosquito will attempt to fly, and will be caught in the kerosene. By this method perhaps the majority of the mosquitoes in a given bedroom—certainly all of those resting on the ceiling—can be caught before one goes to bed.

H. Maxwell Lefroy, when in India, made a trap consisting of a wooden box lined with dark-green baize and having a hinged door. The trap is 12 inches long, 12 inches broad, and 9 inches deep. A small hole, covered by a revolving piece of wood or metal, was made in the top of the box. Owing to the habit of mosquitoes to seek a cool, shady place in which to rest, such as a dark corner of the room or a book shelf, or something of that sort, they will enter the trap, which is put in the part of the room most frequented by mosquitoes, all other dark places being rendered uninhabitable so far as possible. They are driven out of book shelves with a duster or with tobacco smoke, and go into the desirable sleeping place for the day. The door is then closed and fastened, and into the small hole at the top of the box a teaspoonful or less of benzine is introduced. This kills all of the mosquitoes inside, and the box is then thoroughly aired and replaced. In this way Mr. Lefroy was very successful in catching mosquitoes. At one time he averaged 83 a day.

REMEDIES FOR MOSQUITO BITES

The most satisfactory remedy known to the writers, from their personal experience, has been moist soap. Wet the end of a piece of ordinary toilet soap and rub it gently on the puncture, and the irritation will soon pass away. Others have enthusiastically recommended household ammonia, or alcohol, or glycerin. One correspondent marks the puncture with a lump of indigo; another with one of the naphthaline moth balls; another with iodine. R. W. Anderson, of Wando, S. C., states that he has found that by holding his hand near a hot lamp chimney the irritation of mosquito punctures will be relieved instantly.

ABOLITION OF BREEDING PLACES

It has been found that, taking the group of mosquitoes as a whole, their breeding places are of the most diverse character. Some species, however, are restricted in the character of their breeding places. Certain forms, for example, breed only in tree holes; others in accumulations of water in epiphytic plants; other species breed only in the crabholes on sea beaches. Others have more general breeding habits and will live in almost any chance accumu-

lation of water. Certain species breed only in the salt marshes and lay their eggs on mud. Others lay their eggs upon the surface of water. Certain of the species in the more northern States breed only in the pools formed by melting snow, and as these occur at only one time of the year there is but one generation, and the eggs are laid in midsummer or later in such hollows in the earth as will be filled with water from the melting snow in the ensuing spring. Another species, which is frequently very annoying, breeds only in certain permanent swamps, where the larva lives attached to the roots of certain aquatic plants. Still another breeds in the pitchers of pitcher plants (Sarracenia).

The house mosquito[2] in the North and the rain-barrel mosquito[3] and the yellow fever mosquito[4] in the South, however, breed in every chance receptacle of water about residences, and their destruction means the abolition or treatment of all such receptacles.

Where the rain-water barrel and rain-water tank are necessary they should be screened. About a given house the waste places in the immediate vicinity should be carefully searched for tin cans, bottles, and wooden or tin boxes in which water can accumulate and all such receptacles should be destroyed or carried away. It is a good practice to punch several holes in each can as emptied so that, wherever it may be finally deposited, water will not be held in it. The roof gutters of every building should be carefully examined to make sure that they are not clogged so as to allow the water to accumulate. Where the branches of tall trees overhang roofs this is especially likely to occur by the agency of falling leaves or twigs. The chicken pans in the poultry yard, the water in the troughs for domestic animals, the water cup of the grindstone, are all places in which these mosquitoes will breed, and water should not be allowed to stand in them for more than a day or so at a time.

In the South the water accumulating under water tanks should be treated or drained away. The urns in the cemeteries in New Orleans have been found to breed mosquitoes abundantly. The holy-water fonts in churches, especially in the South, have been found to breed many mosquitoes. In slightly marshy ground a favorite breeding place is the footprints of cattle and horses. In one country village, which contained many small vegetable gardens in clay soil, during a rainy season mosquitoes were found breeding abundantly in the water accumulating in the furrows in the gardens.

Even in the house these mosquitoes breed in many places where they may be overlooked. Where the water in flower vases is not changed frequently mosquitoes will breed. They will breed in water pitchers in unused guest rooms. They will breed in the tanks in the water-closets when these are not often in use. They will breed in pipes and under stationary washstands where these are not frequently used, and they will issue from the sewer traps in back yards of city houses during dry spells in the summer time when the sewers have not recently been flushed by heavy rains. In warehouses and on docks they breed abundantly in the fire buckets and in water barrels. Of course such places as these can not be abolished, but they should be treated in accordance with measures indicated in another section of this bulletin.

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[2] *Culex pipiens* L. [3] *Culex quinquefasciatus* Say. [4] *Aëdes aegypti* L.

In country houses in the South, where ants are troublesome, and where it is the custom to insulate the legs of tables with small cups of water, mosquitoes will breed in these cups unless a small quantity of kerosene is poured in. Where broken bottles are placed upon a stone wall, water accumulates in the bottle fragments after rains, and mosquitoes will breed there.

Old, disused wells in gardens are frequent sources of mosquito supply, even where apparently carefully covered, and here the nuisance is easily abated by the occasional application of kerosene. The same thing may be said of cesspools. Cesspools are frequently covered with stone and cement, but the slightest break in the cement, the slightest crack, will allow the entrance of these minute insects, and unlimited breeding often goes on in these pools without a suspicion of the cause of the abundance of mosquitoes in the neighborhood.

Fountains and ornamental ponds are frequent breeding places, and here the introduction of fish, as indicated in another place, is usually all-sufficient. It frequently happens, however, that the grass is allowed to grow down into the edges of ornamental ponds and mosquito larvæ find refuge among the vegetation and so escape the fish. Broad-leaved water plants are also often grown in such ponds, and where these broad leaves lie flat on the surface of the water, as they frequently do, one portion of a given leaf may be submerged so that mosquito larvæ may breed freely in the water above the submerged portion of the leaf, protected from the fish by the leaf itself, the fish rising from below. It is necessary, therefore, to keep the edges of such ornamental ponds free from vegetation, and to choose aquatic plants whose growth will not permit of mosquito-larvæ protection.

In these latter localities not only the house mosquitoes, previously mentioned, or the rain-water barrel mosquitoes will be found, but also some of the other forms, and particularly the malaria-breeding mosquitoes of the genus Anopheles. Some of these breed in all sorts of water accumulations.

In many small country towns, even where there is a water supply, tanks are to be found under the roofs to supply bathrooms. Such tanks should be screened, since mosquitoes gain entrance to the tank room, either through dormer windows or by flying up through the house from below, in search of places to lay their eggs.

About a large old house or a public building there are so many of these chance breeding places that only the most careful and long-continued search will find them all. As an example, in a State hospital, after a search which lasted for many days, and after a treatment of all possible breeding places found, mosquitoes still continued to annoy the patients. Finally in the darkest part of a disused cellar was found a half-barrel with standing water in it, which was giving out mosquitoes at the rate of hundreds per day. Frequent change of water or the use of kerosene will render all such breeding places harmless.

In community work in cities all of the points mentioned must be borne in mind, and in the portions of the community where the residences are for the most part villas, in the absence of swampy suburbs the householders are in the main responsible for their own mosquitoes. There are, however, breeding places for which the municipality may be said to be responsible, and these entirely aside from public

fountains, reservoirs, or marshes. Roadside open gutters or ditches may breed a generation of any one of several species of mosquitoes, including malarial mosquitoes. On a pasture or common, where sod has been removed, water accumulating in the excavation thus formed may breed a generation of malarial mosquitoes. All such accidental breeding places should be abolished by filling in.

It seems unlikely that in any general sewage system mosquitoes may breed in the sewers proper. That they do breed in the catch basins is well known. The purpose of the catch basin is to catch and retain by sedimentation sand and refuse which would otherwise enter the sewer and deposit in it. It is intended to be water-tight and to hold a considerable body of water, which stands in it up to the level of the outlet pipe. Such catch basins are very commonly used in back yards and at the crossings of streets. The water is removed only by rain or when the street or yard surfaces are washed. In dry seasons the period of stagnation may last several weeks, certainly long enough for mosquito breeding. As a matter of fact, mosquitoes in midsummer do breed in such traps or catch basins by millions. These basins may be treated with fuel oil, or the municipal authorities may flush them once a week, carrying away such larvæ as may have hatched. The oiling of such places, however, is best.

Public dumps are great breeding places, because here accumulate old bottles, cans, boxes, bits of tin or iron vessels, and other objects in which water may accumulate for a time. Even a very small quantity of water will make a breeding place for very many mosquitoes. It is quite possible for a half of a bottle to contain enough water to give out literally thousands of mosquitoes. The writers know of one instance where a veritable plague of mosquitoes was traced to a case of empty bottles allowed to remain in a back yard for some weeks in midsummer. It is of great importance to have unburnable refuse from villages and cities dumped in definite places, and the dumps properly cared for. It is usually possible to find a hollow in a convenient location where the dumping may be done systematically and where the unsightliness of the débris as well as the danger of mosquito breeding may be avoided at reasonable expense by keeping the freshly dumped material covered with earth.

Search carefully for all such places, and destroy their suitability as mosquito-breeding places by carting away chance receptacles, by turning over vessels, by filling in excavations, or by treating other receptacles with a film of kerosene, or by introducing fish into fountains and artificial pools.

There is a possibility that under certain circumstances mosquitoes may breed in water accumulating in the troughs of underground-conduit electric railways. There is abundant opportunity for water to accumulate in these troughs, but no exact observations upon mosquito breeding in such situations have been made.

DRAINAGE MEASURES

Drainage measures really form a part of the consideration of the treatment of breeding places. The drainage of swamp areas for agricultural or industrial reasons needs no argument. The value of reclaimed swamp land for various purposes is well known. The drainage of swamp areas primarily in order to improve sanitary

conditions and to reduce the scourge of mosquitoes, which in itself often prevents the proper development of near-by regions, is in operation and needs no argument. Drainage on a small scale for the purpose of doing away with mosquitoes has been practiced for a long time, and in many parts of the country large-scale drainage with mosquito abolition in view is going on, notably in New Jersey and in California. Methods of draining can not be entered into in this bulletin, but it should be pointed out that in case of salt-marsh land the operation is inexpensive, and results of great value have been reached both in California and in New Jersey.

Where the abolition of mosquito-breeding places demands extensive drainage, it is most effective and economical to employ a drainage engineer to map out the entire program before the work is actually begun. The kind of ditching equipment to be used will be governed largely by the conditions prevailing. New Jersey and California have had extensive experience with ditching apparatus.

DESTRUCTION OF LARVÆ BY TREATMENT OF BREEDING PLACES

While it is obviously best to abolish breeding places in the ways mentioned, it often happens that it is not possible to drain, and at least as a temporary expedient it becomes desirable to treat the water so as to kill the mosquito larvæ. Many substances have been tried, and, aside from certain proprietary mixtures, nothing has given such good results as the use of oils. Efforts to find oils that can be used to better advantage than petroleum have failed. Because of its general availability and low cost ordinary low-grade kerosene is very satisfactory. For extensive oiling operations, however, one of the petroleum distillate fuel oils, known also as gas oils, is preferable to kerosene.

In choosing the grade of oil two factors are to be considered: (1) It should spread rapidly; (2) it should not evaporate too quickly. The heavier grades of oil will not spread readily over the surface of the water, but will cling together in spots and the coating will be unnecessarily thick. The rapidity of spread of the film is also important. As to quantity, under still conditions, an ounce of kerosene to 15 square feet of surface space is about the right proportion, and in the absence of wind such a film will remain persistent for 10 days or slightly longer. Even after the iridescent scum apparently disappears there is still an odor of kerosene about the water. In a wind the film of kerosene is frequently blown to one side, but with a change will go back again, so the larvæ are destroyed. Not only are larvæ and pupæ destroyed by the kerosene film, but many adult mosquitoes alighting on the surface of the water to drink or to lay their eggs are killed by it. In California, H. J. Quayle has used a combination of heavy oil of 18° gravity and a light oil of 34° gravity, in the proportion of 4 to 1, respectively. This mixture made an oil that was just thin enough to spray well from an ordinary spray nozzle and yet was thick enough to withstand rapid evaporation. It was applied by a barrel pump where this could be used, and by an ordinary knapsack pump in other regions. A single application was found by Mr. Quayle to be effective sometimes up to four weeks. The army of occupation in Cuba used oil every two weeks.

In New Jersey much experimental work has been done with various larvicides. The authorities in charge of antimosquito work in that State have found very satisfactory distillate fuel oils of a specific gravity ranging between 28° and 38° Baumé with a minimum flash point of 150° F. J. M. Ginsburg, of the New Jersey Experiment Station, has also found that the addition of 1 gallon of crude cresylic acid containing 95 per cent of tar acids to 100 gallons of fuel oil increases the spreading of the oil on both salt and fresh waters covered with dead organic matter and vegetation.

There is some objection to the use of the colored petroleum oils and to kerosene on small ornamental pools on account of the discoloration effected by such oils and their adverse effects on plants. Where it does not seem feasible to utilize fish in such pools, the mosquito larvæ will be destroyed by covering the surface with a film of gasoline, but the effect of this treatment is of short duration.

The use of a spray pump has been mentioned. Small ponds can be sprinkled out of an ordinary watering pot with a rose nozzle, or for that matter pouring it out of a dipper or cup will be satisfactory. In larger ponds pumps with a straight nozzle may be used. A straight stream will sink and then rise and spread until the whole surface of the pond can be covered without waste. The English workers in Africa advise mopping the kerosene upon the surface of the water by means of cloths tied to the end of a long stick and saturated with kerosene.

In Panama a larvicide is being used which is made as follows: 150 gallons of carbolic acid is heated in a tank to a temperature of 212° F., then 150 pounds of powdered or finely broken resin is poured in. The mixture is kept at a temperature of 212°. Thirty pounds of caustic soda is then added and the solution is kept at the same temperature until a perfectly dark emulsion without sediment is formed. The mixture is thoroughly stirred from the time the resin is used until the end. One part of this emulsion to 10,000 parts of water is said to kill Anopheles larvæ in less than half an hour, while 1 part to 5,000 parts of water will kill them in from 5 to 10 minutes. At a larvicide plant at Ancon 4,600 gallons of this mixture was made at a cost of $0.1416 per gallon. Although this mixture has been used to a large extent in Panama, crude oil was also used for streams having a fair velocity.

It has been found that Paris green mixed with fine dust and blown as a powder over the surface of water will kill the top-feeding larvæ of the mosquitoes of the genus Anopheles. In antimalaria operations this method has come into use in many parts of the world. Paris green is mixed with road dust, fuller's earth, powdered soapstone, or something of the sort, in the proportion of 10 per cent by weight of Paris green. This dust may be distributed over breeding waters in many ways. On large areas of marsh the airplane has been found an expeditious and economical means. The cost of effective work at Quantico, Va., in 1927, under the joint auspices of the Public Health Service and the Medical Department of the Navy, was very slight, so far as the cost of material alone was concerned. The effective quantity of Paris green was found to be about 1 pound per acre of marsh. The cost of material was 72 cents per acre.

It has since been shown that Paris green may be used against mosquito larvæ that feed below the surface of the water if it is mixed with moist sand which drags it below the surface film.

THE LOCATION OF DWELLINGS IN RELATION TO MOSQUITO BREEDING PLACES

In the establishment of new town sites and of sites for camps the importance of choosing high, well-drained ground, well removed from mosquito-breeding areas, is obvious. Since most mosquitoes do not travel great distances,[5] especially in nonwooded areas, it is possible to reduce mosquito annoyance by a proper choice of such sites. The possibility of the application of this idea under rural conditions has been shown by studies carried out by W. V. King at Mound, La.

There is a common belief that mosquitoes breed in tall grass, shrubbery, and vines. This idea is erroneous, but such growth may hide water in which breeding may take place. It is well to keep in mind the fact that dense growths of vegetation give protection to mosquitoes and thus encourage them to stay in the vicinity of dwellings. Thus it is obvious that grass and weeds should be kept cut near habitations and dense growths of shrubs and vines avoided. In the South, where houses are not provided with basements, mosquitoes often hide beneath these dwellings. This condition can be remedied to some extent by spraying the supports and the woodwork beneath the floors with creosote oil, which not only preserves the wood but has a distinctly repellent effect on mosquitoes.

IMPOUNDING OF WATER TO CONTROL MOSQUITOES

The breeding of mosquitoes, especially of those species which carry malaria, is greatly favored by the presence, along the banks of streams, ponds, and bayous, of vegetative growths, shallow water, and irregular bank lines. In certain sections of the country the drainage depends upon the presence of an extensive system of sluggish streams and bayous. By raising the water level in such bayous by means of dams put in at proper places, it is possible greatly to reduce the opportunities for mosquito breeding. Such a plan increases the wave action, reduces the quantity of vegetation growing in the water, and enables top minnows and mosquito-feeding insects to carry on their work more effectually. The shelter along the banks of the streams is also reduced, thus giving less protection for the adult mosquitoes and decreasing egg laying.

THE RELATION BETWEEN LIVESTOCK AND MOSQUITOES AND MALARIA

In many parts of the country, especially along the coast where the salt-marsh mosquitoes breed, livestock are greatly annoyed by the attack of these insects. In fact, when swarms of mosquitoes become especially large the cattle which normally feed in the more or less wooded areas along the coast are so beset that their flesh condition and vitality are reduced, and they are ultimately driven into the open

[5] The salt-marsh mosquitoes are notable exceptions to this rule.

country, where the mosquitoes are less numerous. In irrigated areas in the West, as well as in inland swampy areas, livestock and poultry are often greatly annoyed by mosquitoes. No satisfactory method has been found of protecting livestock from mosquitoes. Well-constructed dairy barns may be screened so as to give some immunity from attack, and the use of kerosene-pyrethrum extract sprays will kill great numbers of the mosquitoes and have a slightly repellent action on others. Smudges have also been found to give a certain degree of protection to livestock, both in buildings and in pastures.

The fact that mosquitoes will feed upon various animals and poultry apparently has some protective effect for man. It has been observed frequently that where domestic animals are in close proximity to human beings they will feed upon the former and neglect the latter. It is possible that this may be a factor in reducing the incidence of malaria under certain conditions. The statement has been made that when malaria-infested mosquitoes feed repeatedly upon domestic animals they soon lose their ability to carry the disease.

THE PRACTICAL USE OF NATURAL ENEMIES OF MOSQUITOES

The common goldfish and silverfish destroy mosquito larvæ and should be put in artificial ponds. Top minnows of several species have been introduced successfully in several localities and are great feeders upon mosquito larvæ. Certain species introduced from Texas into Hawaii have been successful, and a small top minnow of the genus Girardinus, known in the Barbados as "millions," has been carried with success to others of the British West India Islands. In Rio de Janeiro another top minnow has been used by the public health service for placing in tanks and boxes where it was impossible to use petroleum. Top minnows are present in all parts of this country and are very useful in destroying mosquito larvæ. The effectiveness of these minnows may be increased by clearing the water of any vegetation or débris which will prevent the minnows from having free access to all parts.

There are many predatory aquatic insects that feed upon mosquito larvæ; others that catch the adults. Certain birds prey upon the adults, and bats also eat them, but the erection of bat roosts in the hope that this action will bring about an appreciable reduction in the mosquito population is not recommended by this department.

DETERRENT TREES AND PLANTS

A great deal has been published concerning the properties of certain growing plants which are said to keep away mosquitoes. Among these may be mentioned several species of Eucalyptus, the castor-oil plant, the Chinaberry tree, and others. Although the evidence in regard to these plants is contradictory, all observations made by scientific men in different parts of the world negative their value; claims that they are valuable are confined to people who have not made thoroughly scientific tests. Evidence is accumulating, however, that certain algæ of the genera Chara and Nitella will render water pools distasteful to mosquitoes.

ORGANIZATION OF THE UNITED STATES DEPARTMENT OF AGRICULTURE

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